Diesel PM Control Technology Options for Complying with TRU ATCM's LETRU[1] (Level 2 – 50% PM Reductions)[2], June 14, 2007

Technology	Company	Design Ready for Trailer/Truck/GenSet TRUs	Demonstrated in Trailer/Truck/Gen Set TRUs	Verified for Trailer/Truck/Gen Set TRUs	Estimated Costs
Passive catalyzed flow-through filter	Thermo King/ FinnKatalyt	Yes/No/Yes	Yes/No/No	Yes/No/No Isuzu D201 MY1985-1998	$4,000 - $5,500 installed (includes pre-installation tests)
Active flow-through filter (sintered metal fiber with periodic electric regeneration)	Rypos	Yes/Yes/Yes	No/No/No	No/No/No	$4,000 to $5,000, installed
Catalyzed Flow-Through Filter	Company A[3]	Yes/Yes/Yes	Yes/Yes/Yes	No/No/No	Unknown.
Catalyzed Flow-Through Filter	Company E[4]	Yes/No/No	Yes/No/No	No/No/No	Unknown
Replace engine with new engine[5] kit	TRU Dealers	Yes/Yes/Yes	NA[6]	NA	Truck: $4,000-$5,000; Trailer/Gen Set: $6,600 - $9,000 with parts & labor.

[1] LETRU means Low-Emission TRU In-Use Performance Standard.
[2] Trade names mentioned herein do not imply ARB endorsement. Any control technology that meets ULETRU could be used to comply with LETRU. Any Alternative Technology that is used to comply with ULETRU could be used to comply with LETRU.
[3] Company A (company identity is confidential until verification is approved).
[4] Company E (company identity is confidential until verification is approved).
[5] Replacing old engine with new or newer engine resets the compliance clock to 7 years after model year (compliance date is based on engine model year).
[6] NA means "Not Applicable" or not required.

TRU Diesel PM Control Technology Options for Complying with ULETRU[7] (Level 3 – 85% PM Reductions)[8], June 14, 2007

Technology	Company	Designed for Trailer/Truck/Gen Set TRUs	Demonstrated in Trailer/Truck/Gen Set TRUs?	Verified for Trailer/Truck/Gen Set TRUs?	Estimated Costs
Active DPF (fuel burner regeneration)	Huss FS-MK Series	Yes/Yes/Yes	No/No/No	Yes/Yes/Yes	$6,000 (installed)
Active regeneration DPF	Company F[9]	Yes/No/No	No/No/No	No/No/No	Unknown
Active regeneration DPF (electric regeneration)	Company G[10]	Yes/No/No	No/No/No	No/No/No	Unknown
Passive DPF (catalyzed wall-flow filter)	Company B[11]	Yes/Yes/No	Yes/No/No	No/No/No	$3,000 to $5,000
Replace engine with new engine[12].	TRU Dealers	Yes/Yes/Yes	NA[13]	NA	Truck: $4,000-$5,000 Trailer: $6,600 to $9,000
Active DPF (uncatalyzed wall-flow filter with electronically controlled intake throttle and Satacene® FBC additive)	European-American consortium[14].	Yes/No/No	Yes/No/No	No/No/No	$2,000

[7] ULETRU means Ultra-Low-Emission TRU In-Use Performance Standard
[8] Trade names mentioned herein do not imply ARB endorsement.
[9] Company F (company identity is confidential until verification is approved).
[10] Company G (company identity is confidential until verification is approved).
[11] Company B (company identity is confidential until verification is approved).
[12] Engines meeting ULETRU not yet available, but replacing the old engine with any new or newer engine resets the compliance clock to 7 years after model year (compliance date is based on engine model year).
[13] NA means "Not Applicable" or not required.
[14] Mayer, A. et al., *Retrofitting TRU-Diesel Engines with DPF-systems Using FBC and Intake Throttling for Active Regeneration.* SAE 2005-01-0662.

Alternative Technologies[15] for Complying with TRU ATCM (if PM emissions eliminated at distribution facility)[16], June 14, 2007

Technology	Company	Designed for Trailer/Truck/Gen Set TRUs?	Demonstrated in Trailer/Truck/Gen Set TRUs?	Verified for Trailer/Truck/Gen Set TRUs?	Estimated Costs
Electric standby (option available for most TRU models)	TRU OEMs	Yes/Yes/NA	Yes/Yes/NA	NA	Truck: $350-$1,000 Trailer: $2,000-$4000, plus facility electric plug infrastructure.[17]
Hybrid e-TRU (diesel engine running generator w/ semi-hermetic electric motor running refrigeration compressor & electric motor-driven fans)	Carrier Transicold – Vector 1800MT	Yes/No/NA	Yes/No/NA In production for multi-temp models	NA	$3,000 to $4,000 over conventional TRU; maintenance costs about 30% less than standard TRU
Biodiesel (100%)	Many producers	Any diesel engine	Yes/No/No	No/No/No Multimedia assessment and in-use verification are required[18]	Same as CARB diesel with tax credits; additional fueling infrastructure costs, if dual fuel at terminal.
Gas to Liquid (GTL) Diesel or Fischer-Tropsch (F-T) Diesel (100% ultra-low aromatic synthetic diesel fuel)	Many companies. Most current production overseas.	Any diesel engine	Yes/No/No	No/No/No Multimedia assessment and in-use verification required. Mandatory quality standards needed.	$7/gal until bulk transport systems needed for volume, then $0.15 to $0.25 per gal more than ULSDI.[19]
Cryogenic Refrigeration (open cycle liquid carbon dioxide)[20]	Thermo King	Yes/Yes/NA	Yes/Yes/NA Operating in EU.	NA	Cost models available. Unit list price is within 10% of diesel unit.
Cryogenic Refrigeration (open cycle liquid nitrogen)	Ukram ecoFridge	Yes/Yes/NA	Yes/Yes/NA Operating in EU.	NA	$18,000/unit, liquid nitrogen infrastructure costs unknown, 25% less hourly operating cost than TRU
Hybrid Cryogenic Temperature Control Systems (cryogenic in conjunction with diesel-powered TRU	Thermo King	Yes/Yes/NA	Yes/Yes/NA In production for truck TRUs.	Not Necessary	Unknown

[15] Alternative Technologies can be used to comply with ULETRU and LETRU if certain qualifications are met (e.g. TRU engine operation is eliminated at distribution centers, and is limited to less than 30 minutes and no more than two TRUs at delivery points). Alternative diesel fuel must be used exclusively. Recordkeeping required.
[16] Trade names mentioned herein do not imply ARB endorsement.
[17] Range of retail costs provided by TRU OEMs.
[18] Company C (company identity is confidential until verification approved).
[19] Ralph Cherillo, Shell Oil Company, April 25, 2007.
[20] Robert Geisen, Manager, Product Engineering, ThermoKing Corporation, March 13, 2002 email to Rod Hill.